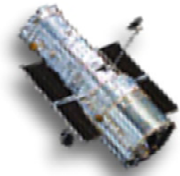# **Hubble** Facts

HST Program Office

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Hubble Space Telescope

Operational Steps for Preserving and Increasing the Lifetime of Hubble Space Telescope

HST Project has sought and continues to seek ways in which HST operations might be changed to prolong the life of the observatory in the absence of normal servicing. The most useful changes are of course those which can help extend the life of the most critical components or the ones deemed most likely to fail prior to the end of the mission. Some of the approaches identified have in fact already been implemented, while other more difficult changes are under study for feasibility and cost/schedule requirements.

Motivation
There currently remains only one HST servicing mission on the shuttle manifest and that mission has been fully-subscribed. Operational changes are the remaining opportunity to preserve mission life.

Modifications Already in Place
After Servicing Mission 3b (SM3b) in March, 2002, HST Project began to study and implement the easiest and most productive of such changes. Perhaps the most important of these changes was the decision to *operate only 3 of the six on-board gyros at any one time*. Prior to this change, 4 out of the 6 gyros were always turned on, with 3 of them being used in the

actual control law and the 4th running as a backup that could immediately be brought into the control law if a problem arose with one the 3 primary gyros. This approach has the advantage that the telescope does not enter into a "safemode" when an operational gyro fails, since the backup gyro (i.e., the 4th) immediately takes over to enable continued normal operations. However, gyro lifetime appears to be correlated with amount of actual "run time", so always running a 4th, mostly unneeded, gyro decreases the total time that a given set of gyros can support operations. The normal HST operations mode now has only 3 gyros turned on at one time, with the remaining healthy gyros (as well as the failed gyros) turned off to maximize their lifetime. We accept the risk of temporarily entering a "safemode", in order to prolong the long-term life of the observatory. Finally, for the current set of gyros, we have developed a flight software "workaround" that will *enable use of the "spare" Gyro #6, even if its anomalous bias performance degrades further with time*. This is critical since it provides us a spare which is vital to enabling continuing operations of HST until SM4 can be executed, especially with the delay caused by the loss of shuttle Columbia.

Another life-extending technique is to *minimize the frequency of movements ("slews") of* the *solar arrays* to optimize their angle to the sun as the telescope is re-pointed at different targets. A target scheduling process that minimizes the need to execute such slews thus extends the lifetime. The gimbal mechanisms on the *high-gain antennas* require a different approach - a slow continuous motion ensures an even distribution of lubricant and eliminates sudden rapid motion to a new pointing angle. It is also useful to *minimize the cycling of the S-band transmitter* (SSAT) by using less frequent, but longer data dumps to the ground. This is possible due to the larger-capacity of solid-state recorders added to HST during a previous servicing mission (replacing older, mechanical recorders which held much less data and thus required more frequent downloads). Telescope scheduling processes are now in place to satisfy all three of these constraints.

In addition to the modifications noted above, we have stopped the periodic Fine Guidance Sensor (FGS) "spin tests" and changed the way in which we use the FGS in its coarse track mode to minimize those cycles; both steps prolong the lifetime of the pointing control system. We have minimized cycling of the Power Control Unit's K-relay, which controls current flow from the solar arrays to the batteries, and shortened data re-dumps to cut down on recorder and transmitter cycling. The battery charging methodology has also been modified to maximize battery lifetime.

Possible Future Modifications
A number of possible future modifications to HST operational procedures to increase observatory lifetime are also under study. The most important of these is likely the investigation of *a possible "2-gyro" science operations mode*, since the high-precision

gyros needed to enable adequate pointing control of HST are the items most frequently requiring replacement. If SM4 is substantially delayed or if it is desired to operate HST to 2010 or beyond without another servicing mission, it is unlikely the currently required 3 gyros will be available to maintain operations till the next servicing or nominal end-of-mission. The HST Program Office is therefore studying the feasibility of operation under only 2 gyros – with the goal of ensuring a telescope jitter of no more than 30 milli-arcseconds. This would ensure HST's ability to continue world-class science in the absence of 3 operational gyros for an additional 12 to 15 months. Impacts on slew and target acquisition times are still under evaluation, since they are likely to increase under 2-gyro control. More information on the 2-gyro control development effort is available on a separate fact sheet.

Other modifications under study include flight software modifications that would enable *operations with 1 FGS and Fixed Head StarTrackers (FHST)* in place of the 2 FGS's currently required. New operational procedures that would support: a 2-gyro safemode, the use of 4 (vs. 2) TDRSS communication satellites to increase scheduling flexibility, autonomous dumping of the Solid State Recorders, and the use of the HST 486 computer to stage data for the prime, but smaller NSSC-1 computer are all also under study.